LOCALIZATION OF THE ENERGY DENSITY OF GRAVITATIONAL FIELD IN THE MODEL OF NONDECELERATIVE UNIVERSE

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Abstract: *There is a paradigm stating that gravitational field is of non-localizable and stationary nature. Contrary, in our model of nondecelerative Universe it is hypothesized that gravitational field is always localizable and nonstationary. This assumption allows localizing its energy density.*

1: INTRODUCTION

Any aspect of gravitational field can be expressed by corresponding metrics. A spheric symmetric field can be described by Schwarzschild metric, rotating charged massive objects by Kerr – Newman metric, nonstationary gravitational field by Vaidya metric, singularities of Schwarzschild metric are eliminated using Finkelstein metric etc. All the mentioned metrics describe strong gravitational fields. Neither of the metrics (excluding that of Vaidya) is able to localize gravitational field energy density. Current cosmological models do not comply with the Vaidya metric. We suppose, the model of Expansive Nondecelerative Universe (ENU) might conform to Vaidya metric.

2: NONDECELERATIVE UNIVERSE MODEL

Our model of the Universe (Expansive Nondecelerative Universe, ENU) [1],[2] is based on a simple premise that the rate of the Universe expansion is constant and equal to the speed of light. Moreover, the Universe mean energy density is identical to its critical energy density. There are three limiting conditions characterizing the ENU model, namely

$$\Lambda = 0 \tag{1}$$

where Λ is the cosmological constant,

$$k = 0 \tag{2}$$

where k is the curvature, and

$$a = c\,t_U \tag{3}$$

where a is the scale factor, c is the speed of light in the vacuum, t_U is the cosmological time. Their present ENU-based values are following: $a = 1.229 \times 10^{26}$ m; $t_U = 1.373 \times 10^{10}$ yr. Within the classic models of the Universe, the flat Universe is required to gradually decelerate its expansion. It is a case where the gravitational force affects the Universe GLOBALLY. Contrary, in the ENU, the gravity affects it only LOCALLY.

The dynamic nature of the ENU is described by Friedman equations. Introducing a dimensionless conform time η, the equations can be expressed as follows:

$$\frac{d}{d\eta}\left(\frac{1}{a}.\frac{da}{d\eta}\right) = -\frac{4\pi G}{3c^4}a^2(\varepsilon + 3p) \tag{4}$$

$$\left(\frac{1}{a}.\frac{da}{d\eta}\right)^2 = \frac{8\pi G}{3c^4}a^2\varepsilon - k \tag{5}$$

where ε is the energy density, p is the pressure and the scale factor a is expressed as

$$a = \frac{da}{d\eta} \tag{6}$$

Introducing the conditions (1) to (3) into relations (4) and (5), we get

$$\varepsilon = \frac{3c^4}{8\pi G a^2} \tag{7}$$

$$p = -\frac{\varepsilon}{3} \tag{8}$$

The energy density can be expressed also in the form

$$\varepsilon = \frac{3m_U c^2}{4\pi a^3} \tag{9}$$

where m_U is the mass of the Universe ($m_U \cong 8.673x10^{52}$ kg).

Combining of (7) and (9) one obtains

$$a = \frac{2G\, m_U}{c^2} \tag{10}$$

It follows directly from (10) that a time evolution of the matter must occur. An amount of the mass created in one second is δ

$$\delta = \frac{dm_U}{dt} = \frac{m_U}{t_U} = \frac{c^3}{2G} \tag{11}$$

It means that an amount of the matter created in our Universe in a second is equal to about 10^5 Sun mass. In the inflationary model, the same amount of matter is emerging from beyond the horizon. It is not too much matter if the Universe dimensions are taken into accout. For the sake of illustration, it represents a proton in a cube of 1 km^3 within a year. There is no global scale gravity in the ENU which could decelerate the Universe expansion.

The ENU model is this in compliance with the Hawking's statement that the total mass-energy of our Universe must equal precisely to 0. It means that the matter, representing the positive component of the energy, is just compensated with the gravitational field, representing the negative component of the energy. The conservation laws are therefore obeyed.

However, the creation can be understood also differently. We suppose that the mass of the elementary particles decreases in time and the decrease is compansated through an increase in their quantity. We are able to register only this increase which appear as the matter creation in spite of preservation of their total mass. There must thus exist a nonstationary gravitational field in the ENU model. Introducing the transformation

$$m \to m(t_U) \tag{12}$$

the mass depends on the cosmological time ($m_{(t)}$).

It holds:

$$\frac{dm_{(t)}}{cdt} = \frac{m_{(t)}}{a} \tag{13}$$

In this situation it is possible to localize the energy density of gravitational field.

3: LOCALISATION OF WEEK GRAVITATIONAL FIELD

As a starting point, Einstein equation

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{14}$$

is taken. Divergence of this equation leads to gravitational energy density ε_g in the form

$$\varepsilon_g = -\frac{c^4}{8\pi G} R \tag{15}$$

where R is the scalar curvature.
Vacuum scalar curvature is equal to zero. It holds:

$$R = \frac{\Delta\varphi}{c^2} = 0 \tag{16}$$

φ is Newton potential.
Gravitational force being a far-reaching force acts in principle up to infinity, it is measurable, however, only to a certain distance called effective range r_{ef}. Its meaning lies in a postulate that in the ENU, the effect of gravitation can be displayed only in such a distance, in which the absolute value of the gravitational energy density is higher than the critical energy density of the Universe.

$$r_{ef} = \left(r_g a\right)^{\frac{1}{2}} \tag{17}$$

Non-relativistic gravitation potential can be thus express a

$$\Phi = \varphi \exp - \left(\frac{r}{r_{(ef)}}\right) \tag{18}$$

Within the distances shorter that the effective range, this potential is almost identical to Newton potential. At distances $r > r_{ef}$, the potential approaches zero value.

For weak gravitational field the following members of metric tensor apply:

$$g_{\mu\nu} = diag\left(-1 + \frac{2Gm_{(t)}}{rc^2}, 1 - \frac{2Gm_{(t)}}{rc^2}, 1 - \frac{2Gm_{(t)}}{rc^2}, 1 - \frac{2Gm_{(t)}}{rc^2}\right) \tag{19}$$

It holds:

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu} \tag{20}$$

In our case:

$$\eta_{\mu\nu} = diag(-1,1,1,1) \tag{21}$$

$$h_{\mu\nu} = diag\left(\frac{2Gm_{(t)}}{rc^2}, -\frac{2Gm_{(t)}}{rc^2}, -\frac{2Gm_{(t)}}{rc^2}, -\frac{2Gm_{(t)}}{rc^2}\right) \tag{22}$$

It must then hold for scalar curvature:

$$R = 2\frac{d\Gamma^0_{00}}{dr} = \frac{2Gm_{(t)}}{ar^2c^2} \tag{23}$$

The identical result is obtained using Vaidya metric, and Einstein or Tolman pseudotensor [3], [4].

The scalar curvature can be expressed also by another way applying Yukawa potential

Φ . It holds:

$$R = h_{\mu\mu}\frac{\Delta\Phi}{c^2} = \frac{2Gm_{(t)}}{ar^2c^2} \tag{24}$$

$$\mu = (0,1,2,3)$$

Combining relations (15), (23) and (24) it follows for the energy density of weak gravitational field:

$$\varepsilon_{(g)} = -\frac{c^2}{8\pi G}h_{\mu\mu}\Delta\Phi = -\frac{c^4}{4\pi G}.\frac{d\Gamma^0_{00}}{dr} = -\frac{m_{(t)}c^2}{4\pi ar^2} \tag{25}$$

At the same time, the identity must hold:

$$\frac{d\Gamma^0_{00}}{dr} = \frac{h_{\mu\mu}}{2c^2}\Delta\Phi \tag{26}$$

4: LOCALISATION OF STRONG GRAVITATIONAL FIELD

Given the localization of the energy density for weak fields, this approach can by used to transfer the method into the area of strong gravitational fields. To do it, relation (12) will be introduced to Schwarzschild metric. As a result, three new nonzero members Γ^0_{00} , Γ^1_{10} and Γ^0_{11} are obtained.

With regard to these Christoffel's symbols, nonzero members of Ricci tensor must be calculated and attributed to the corresponding components of energy-momentum tensor.

Outside the area of the central body there is only one non-zero member

$$T^1_0 = -\frac{c^4}{8\pi G}.\frac{r_{(g)}}{ar^2} \tag{27}$$

The component T^1_0 is identical to relation (25) for weak fields. Decreasing the *r* value, the absolute value of T^1_0 will increase to infinity. This is why the positive and negative part sof the energy-momentum tensor are mutually compansated and in the our model no singularity exists.

5: CONCLUSIONS

It follows of the paper that due to nonstationary gravitational field, infinities in the energy-momentum tensor are mutually compensated and thus singularities cannot exist.

Schwarzschild metric is not the optimal approach, the better way would lie in Kerr – Newman metric.

The ENU model allows a new view of gravity and the Universe, however, at the expense of chase in the paradigm on nonlocalizability and stationary character of gravitational field.

References:

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